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(54) MIXING MACHINE

(71) We, BARMAG BARMER MASCHINENFABRIK AKTIENGESELLSCHAFT, a body corporate organised under the laws of Germany of Wuppertal, Germany, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a machine for mixing plasticisable synthetic resins and additives added to them, preferably for mixing and agglomerating heterogeneous thermoplastic plastics powder mixtures, the machine being of the type comprising a housing and a drivable cylindrical rotor received in the housing with a rotatng fit. Grooves and shearing lands separating the grooves in the peripheral direction are provided on the confronting surfaces of the rotor and housing.

Various forms of machines for mixing plasticisable synthetic resins and additives added to or premixed with them, for example fillers, lubricants, stabilisers, pigments and antistatic agents, are known. The mixing elements used vary in design depending on whether mixing is intended to be dispersive (shearing, dispersion) or distributive (distribution, incorporation) *cf.* Schiedrum, Kunststoffe, Vol. 63, 1973 No. 6 pages 355 to 361. In either case, the object of the mixing process is to distribute all the additives uniformly in the main substance even if they are only introduced in low concentrations, the final mixture being present either in solid form, for example as an agglomerate, or in the form of a homogeneous melt.

Known mixing machines, for example those described in German Patents Nos. 902,789; 1,197,438 and 1,198,051 and German Auslegeschrift 1,529,964, comprise radially interengaging mixing or kneading elements arranged for rotation with a rotor of a screw extruder and fixedly secured to the rotor housing. The disadvantage of mixing machines of this type is that the presence of mixing elements or disc assemblies makes removal of the rotor for example for cleaning, inspection or repair, a time-consuming operation. In cases where the radially interengaging mixing elements are fixed alternately to the rotor and to the housing, quick removal of the rotor is totally impossible. Such a mixing machine is therefore not suitable for processing hard polyvinylchloride because rapid removal of the rotor is necessary to protect the rest of the machine in the event of power failures. Another disadvantage of known mixing machines is that, in cases where several mixing elements are arranged on the rotor and in the housing for improving the mixing effect, predetermined gaps have to be present between the rotating mixing elements and the fixed mixing elements to ensure proper operation and avoid jamming of the axially opposite annular surfaces. However, the axial gaps result in varying mechanical and thermal stressing of the material being mixed and prevent optimum, reproducible mixing of the various ingredients due to the complex and uncontrollable flow process. For example, the fluctuating residence time of the material being mixed in the mixing machine in the case of heat-sensitive synthetic resins results in damage to the material being mixed and, ultimately, in a fluctuating quality of the end products.

In addition to the mixing machines described above, however, there is another known mixing machine (German Patent 1,037,698), in which systems of axially extending grooves or channels are arranged opposite one another on a drivable, cylindrical rotor and a housing surrounding the rotor with minimal radial clearance. These grooves or channels are separated in the peripheral direction by shearing lands which are spaced from one another. Unfortunately, the advantage of this machine, namely that the rotor can be removed fairly easily by axial ejection is offset by the disadvantage that shearing and mixing of the plastics with the additives introduced into them take place uncontrollably, and that only relatively large agglomerates can be size-reduced

between the shearing lands. The strand of material extruded through the mixing machine is sheared only once in the longitudinal direction and distributed between the grooves in the rotor and housing. It is purely a matter of chance whether the particles of material are subjected once again to discrete shear stressing in the course of their passage through the machine, because a controlled, radial flow from the grooves of the rotor into the grooves of the housing and *vice versa* is not induced, nor can it be achieved with the means proposed. Another disadvantage is that the groove systems are not self-cleaning so that any blockages occurring, for example as a result of inadequately melted agglomerates cannot be automatically removed and this lack of self-cleaning is to the detriment of the homogeneity of the mixture and the quality of the product.

The disadvantages referred to above can largely be eliminated by the arrangement shown in British Patent 930,339. In this case, several groove systems are arranged axially one behind the other and offset relative to one another in the rotor and housing. By axially interrupting the grooves, the material is forced to flow from the groove system of the rotor to the groove system of the housing and from there back to the groove system of the rotor.

One disadvantage of this arrangement, however is that the groove systems in the rotor and in the housing are expensive to produce. This applies particularly to the groove system in the housing which, because of its small internal diameter is extremely difficult to machine.

An object of the present invention is to provide a mixing machine comprising a readily axially removable rotor, which has the processing advantages of controllable shearing and mixing of the various streams of material and which is easy to manufacture and can be adapted to meet different requirements in regard to effectiveness and quality of mixing.

According to the invention there is provided a machine for mixing a plasticisable synthetic resin and at least one additive comprising a housing and a drivable cylindrical rotor mounted with a rotating fit in the housing, grooves and shearing lands separating the grooves in the circumferential direction being provided on the confronting surfaces of the rotor and housing, wherein the grooves and lands are defined by a plurality of inner and outer profile rings arranged fixedly and in axial abutment on the rotor and/or in the housing in such a sequence as to form radially opposite sets of peripherally distributed grooves of defined length, the grooves in the rotor being offset relative to and partially axially overlapping those in the housing.

The profile rings are advantageously grooved rings carrying groove sets defined by, for example, spur teeth or helical teeth. In the former case the groove base is formed by the short base line and the groove inlet and outlet by the sides of a preferably equilateral trapezium. Helical teeth are preferred because in that case, the grooved rings impose a component in force in the delivery direction on the flow of material and thus assist in delivery. The fact that the grooves of the rotor are offset relative to the grooves in the housing induces a flow of material from the rotating system to the fixed system and back again. This is the case because the respective groove systems have only a limited length in the axial direction.

The mixing machine can be connected to the output end of a screw extruder although it may instead be an independent machine with its own drive.

When used in conjunction with a screw extruder, it is advantageous to make the diameter of the rotor of the mixing machine larger than the diameter of the screw of the screw extruder because in this way, a larger number of grooves can be provided on the periphery of the profile rings whilst, at the same time, the radial velocity essential to the mixing effect is increased. It is desirable to introduce, for example, waxes or liquid additives such as antistatic agents, in the production of synthetic fibres at the input end of the mixing machine under pressure through a spacer ring in the housing provided with a radial channel. In this way, such additives are uniformly distributed over the groove system of the grooved ring radially opposite the spacer ring.

The invention is described in more detail below with reference to the accompanying drawings which only show a preferred embodiment and in which:

Figure 1 is a longitudinal section through the mixing machine in conjunction with the output end of a screw extruder.

Figure 2 shows a grooved ring for the rotor in elevation and cross-section.

Figure 3 shows a spacer ring for the rotor in elevation and in cross-section.

Figure 4 shows a grooved ring for the housing in elevation and cross-section.

Figure 5 shows a spacer ring for the housing in elevation and cross-section.

Figure 6 is a perspective view of axially abutting grooved and spacer rings of the rotor and housing.

Figure 7 is a cross-section through two radially co-operating grooved rings, the grooves in one ring being spaced apart by a different amount to the grooves in the other ring.

Figure 8 shows in elevation and cross-

section a spacer ring with an annular groove and radial bores for introducing additives.

Figure 1 shows a mixing machine 1 according to the invention immediately adjacent the output end of a screw extruder 2. The screw extruder comprises a barrel 3, and a screw 5 having a helical screw flight 4. A rotor 6 of the mixing machine 1 is connected to the output end of the screw 5 by means of a threaded bolt 7 which is screwed into a thread at the head of the screw 5. The housing 8 of the mixing machine, which coaxially surrounds the rotor 6, is connected to the barrel 3 of the screw extruder by flanges 9, 10 which are fixedly connected by standard clamps 11. The housing 8 of the mixing machine may alternatively be integral with the barrel 3 of the screw extruder. However, the flanged construction is preferred because it increases the flexibility of the extruder and because the mixing machine can readily be adapted in its effectiveness to meet varying requirements by using an extended housing and a larger number of mixing elements.

A plurality of profile rings 14 and 15 are alternately arranged, axially abutting one another on the rotor 6, being prevented from rotating by means of fitting keys 12 and 13. The rings 14 and 15 of which the ring 14 is referred to hereinafter as the inner grooved ring and the ring 15 as the inner spacer ring, are shown in detail in Figures 2 and 3 and are described in more detail below with reference to those Figures. The rings 14 and 15 are axially secured on the rotor 6 by a screw tip 17 screwed on by means of threaded bolts 16.

Outer profile rings 18 and 19 are similarly arranged in axial abutment in the housing 8 of the mixer, being prevented from rotating by means of fitting keys 20 and 21. The ring 18 is hereinafter referred to as the outer grooved ring and the ring 19 as the outer spacer ring. They are shown in detail in Figures 4 and 5 and are described in more detail below with reference to the drawing. The rings 18 and 19 are axially secured by means of a ring insert 23 held in position by screws 22. An extrusion die (not shown) may be connected in known manner to the flange 24 of the housing of the mixing machine, being joined to this housing by means of screws or clamps.

The inner and outer profile rings of the mixing machine are shown in cross-section and in elevation in Figures 2 to 5. The grooved rings 14 and 18 each have frontal chamfers 25, 26 and 27, 28 in which corresponding chamfers 29, 30 and 31, 32 of the spacer rings 15 and 19 abut in the axial direction. This is shown in perspective in Figure 6. The grooved rings 14 and 18 comprise on their outer and inner circumference, respectively, peripherally distributed axially parallel longitudinal grooves 33 and 35 with rounded bases and a trapezoidal axial profile which are separated in the peripheral direction by shearing lands 34 and 36 defining the external and internal diameter of the rings. The longitudinal grooves 33, 35 are axially limited by the spacer rings 15 and 19, so that overflow of the material being mixed within a groove system is prevented or could only occur with shearing by means of the shearing lands 34 and 36. To enable them to be secured on the rotor and in the housing of the mixing machine, all the profile rings comprise inner or outer longitudinal grooves 37, 38 and 39, 40 in which the above-mentioned fitting keys 12, 13 and 20, 21 engage.

All the inner profile rings 14, 15 have the same external diameter. This external diameter is such that the rotor is a rotating fit in the housing. The width of the profile rings is preferably such that, in the housing and on the rotor, one spacer ring and one grooved ring always have the same overall width. The length of the shearing zone is governed by the selected length of the groove inlet and groove outlet zone and is defined by the chamfer angle of the profile rings.

Figure 6 is a perspective view showing the inner and outer grooved and spacer rings for the rotor and the housing. It can be seen how the profile rings abut one another axially and how the groove system provided in the grooved rings 14 and 18 is axially limited by the spacer rings 15 and 19. The radial co-operation between the inner and outer profile rings is shown in Figure 7. The grooved rings 14 and 18 have an unequal groove interval so that, in any angular position of the rotor relative to the housing, there is a throughflow connection for the flow of material between at least some of the radially opposite grooves. However, this can alternatively be achieved through a slight overlap between the grooves in the peripheral direction by providing the grooves in the grooved rings of the rotor and housing with different widths for the same number of grooves.

The profile rings are arranged in such a sequence in the housing and on the rotor (cf. Figure 1) that a spacer ring in the housing is situated radially opposite a grooved ring on the rotor, whilst a grooved ring on the housing is situated radially opposite a spacer ring on the rotor. In this way, and by virtue of the axial limitation of the grooves, the material is constantly caused to flow from the grooves of the housing to the grooves of the rotor and vice versa. This enables an additive to be dispersed very uniformly in a synthetic resin by means of this mixing machine.

If an additive in the form of a liquid,

wax or paste is added to the synthetic resin, it is of advantage to use a special form of spacer ring 41 which is shown in detail in Figure 8 and to arrange it at the beginning of the mixing machine in the housing 8 (see Figure 1). The spacer ring 41 has the width and the other dimensions of the other spacer rings 19 in the housing, but has formed in its outer periphery an annular channel 42 from which one or more radial bores 43 lead to the inner periphery. The annular channel 42 in the spacer ring 41 is connected to a bore 44 in the housing of the mixing machine through which the additives, for example pigments, stabilisers or antistatic agents or the like, are introduced by means of a suitable metering pump 45 (not shown in detail) in order to be mixed with the synthetic resin being conveyed through the screw 5.

WHAT WE CLAIM IS:—

1. A machine for mixing a plasticisable synthetic resin and at least one additive comprising a housing and a drivable cylindrical rotor mounted with a rotating fit in the housing, grooves and shearing lands separating the grooves in the circumferential direction bting provided on the confronting surfaces of the rotor and housing, wherein the grooves and lands are defined by a plurality of inner and outer profile rings arranged fixedly and in axial abutment on the rotor and/or in the housing in such a sequence as to form radially opposite sets of peripherally distributed grooves of defined length, the grooves in the rotor being offset relative to and partially axially overlapping those in the housing.

2. A machine as claimed in claim 1, wherein the profile rings are in the form of alternatively arranged grooved rings and spacer rings, the groove set formed in the grooved rings being limited in the longitudinal direction by lateral surfaces of the spacer rings.

3. A machine as claimed in claim 2, wherein the grooves in the grooved rings are defined by spur teeth, the groove base being formed by the short base line and the groove inlet and outlet by the sides of a trapezium.

4. A machine as claimed in claim 3, wherein the said trapezium is equilateral.

5. A machine as claimed in claim 2, wherein the grooves in the grooved rings are defined by helical teeth which promote the flow of the material being mixed.

6. A machine as claimed in any preceding Claim wherein the housing is connected to the output end of a screw extruder and the rotor is drivably connected to the screw of the screw extruder.

7. A machine as claimed in any preceding Claim wherein a spacer ring provided in the housing of the mixing machine comprises at least one radial bore which communicates with a metering pump.

8. A mixing machine substantially as herein described with reference to the accompanying drawings.

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1475216 COMPLETE SPECIFICATION
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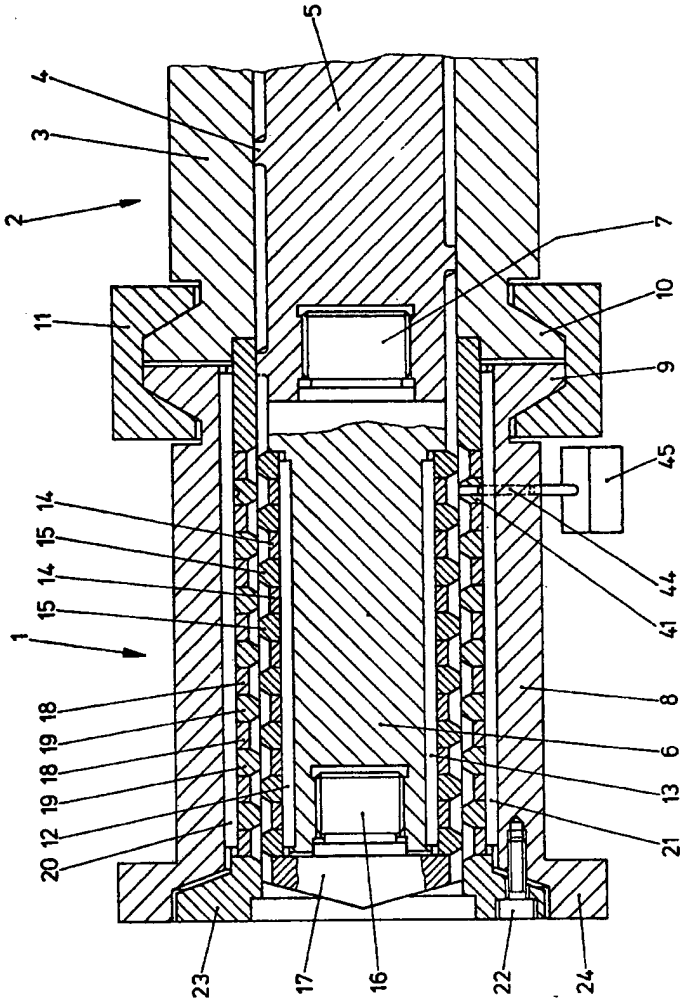

Fig.1

1475216 COMPLETE SPECIFICATION
4 SHEETS *This drawing is a reproduction of the Original on a reduced scale*
Sheet 2

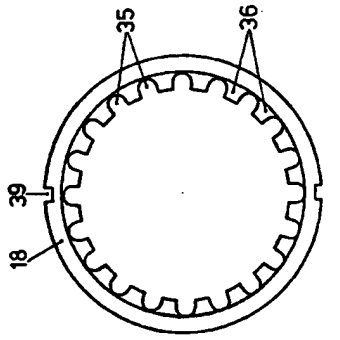

Fig.4b

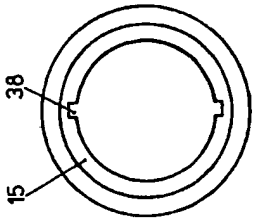

Fig.3b

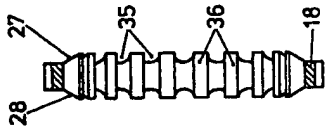

Fig.4a

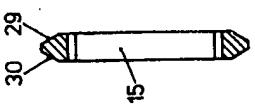

Fig.3a

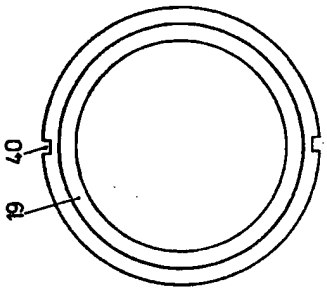

Fig.5b

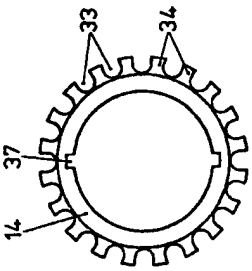

Fig.2b

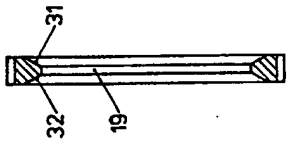

Fig.5a

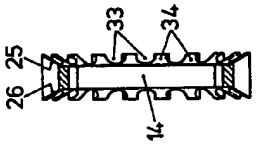

Fig.2a

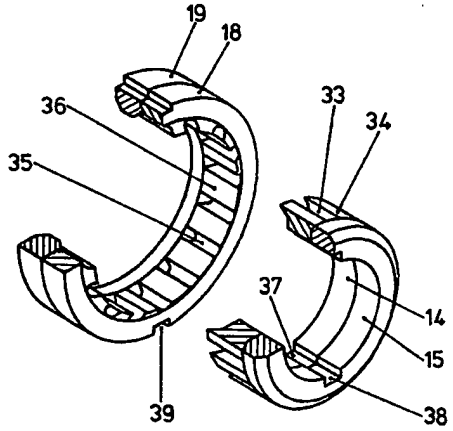

Fig.6

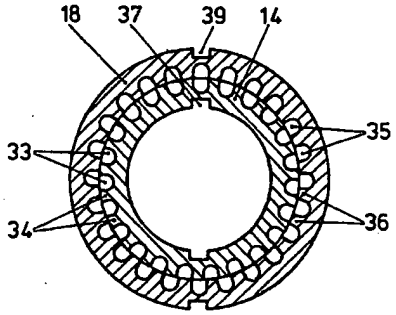

Fig.7

1475216 COMPLETE SPECIFICATION
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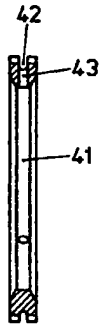

Fig.8a

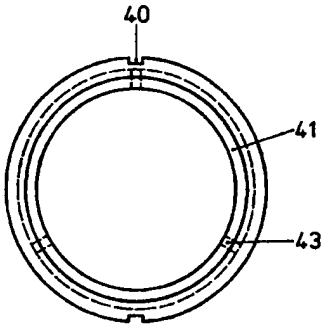

Fig.8b